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Short communication

Cutting affects growth of *Potamogeton lucens* L. and *Potamogeton compressus* L

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ABSTRACT

Effects of cutting on the growth of *Potamogeton lucens* L. and *Potamogeton compressus* L. were studied indoor under experimental conditions. Plants were cut every time they reached the water surface, applying three depth treatments at which the plants were cut; halfway down the water column, at three-quarters down the water column and at the sediment–water interface. For both species short term negative effects of cutting on biomass production and survival were observed. *P. lucens* seemed to be the more tolerant species as only below-ground biomass was significantly lower when cutting biomass at the sediment–water interface together with a downward trend in shoot biomass at increasing cutting depth. The low below-ground biomass (less than 20% of that in the controls) was caused by the death of most plants in this treatment. *P. compressus* was more vulnerable with every treatment resulting in significantly lower below-ground and green shoot biomass production. The lowest biomass for *P. compressus* was observed when plants were cut at the sediment–water interface with values more than 80% lower compared to the controls, while cutting halfway and at three-quarters resulted in values 30–50% lower compared to the controls. Long term effects of cutting on *P. lucens* might occur through decreased development of the rhizome network. Long term effects on reproduction of *P. compressus* might be expected as flowering decreased when cut at the sediment–water interface, while turion formation only occurred in the uncut controls. Additionally, the decreased biomass production by *P. compressus* may lead to a competitive disadvantage in the field as fast-growing, disturbance tolerant species such as *Elodea nuttallii* (Planch.) St. John may outcompete the species. Creating patchiness in mowing height and frequency or applying a mowing regime that leads to reduced biomass development while species still survive might create opportunities to both maintain the water transporting function of drainage ditches while preserving the species in the system.

1. Introduction

Macrophytes are essential for the ecological functioning of aquatic systems since, amongst others, they offer habitat for fauna due to their architecture (Waters and San Giovanni, 2002; Christie et al., 2009; Bakker et al., 2010) and remove nutrients from water and sediment (Bouldin et al., 2004; Cooper et al., 2004). Eutrophication has led to a decreased plant diversity in many systems (Thiébaut and Muller, 1998; Hilt et al., 2006; Bakker et al., 2010) while the development of fast-growing species like *Elodea* nuttallii (Planch.) St. John and *Myriophyllum spicatum* L. is often promoted (Nichols and Shaw, 1986; Mesters, 1995), especially in small and shallow aquatic ecosystems like drainage ditches. This increased productivity of fast-growing species under eutrophic conditions results in the need to remove vegetation more frequently to prevent drainage problems. Mowing can affect plant species composition (Beltman, 1987; Best, 1994) and a decrease in species diversity is often observed in systems subject to maintenance (Baattrup-Pedersen et al., 2003; Peeters, 2005). Mowing damages green parts of the plant and may also uproot plants. If below-ground parts and green shoots do not remain present after mowing this will lead to the disappearance of species during the growing season. Maintenance may also restrict the possibilities for species to produce propagules for the next growing season such as seeds and turions, thereby possibly jeopardizing long term survival of species. Contrastingly, disturbance tolerant species may profit from a high level of disturbance by expanding and eventually becoming dominant in the system (Bornette et al., 1994; Di Nino et al., 2005), accelerating the decrease in biodiversity of the system.

Potamogeton species (Pondweeds) are a major component in many macrophyte communities, are found worldwide with around 100 different species (Pip, 1987; Wiegleb and Kaplan, 1998) but have also declined in parts of Europe due to human influences among which maintenance is one of them (Wiegleb et al., 1991). The genus contains species that are indicators for different levels of water quality (Sastroutomo, 1981) and disturbance (Wiegleb et al., 1991). Some species for instance occur at eutrophic conditions and

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invest a large part of their energy in subsurface overwintering parts such as rhizomes (e.g. *P. lucens* L., *P. gramineus* L. and *P. natans* L.) (Wiegleb et al., 1991) while other species may occur as annuals at mesotrophic conditions and produce above ground reproductive parts such as seeds and turions (e.g. *P. compressus* L. and *P. acutifolius* Link. (Wiegleb and Kaplan, 1998; Pot, 2003)). In both Britain and the Netherlands this species is endangered and in the latter it has a protected status.

In the field, eutrophication and increased maintenance intensity often occur simultaneously. Therefore, the disappearance of species is difficult to attribute to either eutrophication or maintenance. In this paper focus is on the effects of maintenance and the effects of cutting on the performance of two Pondweed species is investigated. The main objective of the study is to quantify the effects of cutting on the growth of *P. lucens* L. and *P. compressus* L. It is hypothesized that (1) cutting will result in decreased biomass production, (2) cutting away more biomass will cause less regrowth and (3) *P. lucens* will be more tolerant to cutting than *P. compressus* due to the differences in growth form (respectively high and low root:shoot ratio). To test these hypotheses an experiment was conducted in which 4 different cutting treatments were applied to both species. This was done under comparable conditions during a period of 6 months.

2. Materials and methods

2.1. Setup

Transparent cylinders with a closed bottom, 45 cm high and 14 cm in diameter were used as test microcosms. Each microcosm was filled with 5 cm of sediment and 5 L of Smart and Barko culture solution without nutrients (Smart and Barko, 1985). All microcosms were kept at a water temperature of 20 °C and a photoperiod of 16 h light:8 h dark. Philips Son Agro 430 W HPS lights were used at a mean light intensity of 64 W/m^2 (Philips, 2012). Water levels were checked weekly and were kept constant by adding demineralized water. All microcosms were aerated continuously and pH was measured every 2 weeks. pH was kept at a value between 6 and 8 by adding drops of sodium hydroxide or hydrogen chloride solution if needed while measuring the change in pH. Adjustments of pH were only needed occasionally. Therefore pH fluctuations likely had limited effect on the results of the experiment. To suppress phytoplankton bloom 20 individuals of *Daphnia magna* were added, which were replenished if necessary. Biomass of filamentous algae was removed by hand.

Sediment was collected from a drainage ditch in the Netherlands that accommodated both species and was located in the Natura 2000 area 'De Wieden' (52°45′49.81″N, 6°5′59.58″E). Prior to the experiment, plants of both species were cultivated under the same conditions as the main experiment to obtain sufficient material. For the main experiment, *P. lucens* plants with a horizontal rhizome of 9 cm long and an attached vertical shoot of 5 cm long were used. For *P. compressus* turions with a mean length of 6 cm were used. One plant fragment was planted in each of the microcosms. The Smart and Barko solution contained no nutrients to prevent algal blooms, assuming the Pondweeds would acquire nutrients from the sediment. It was assumed that nutrient supply did not influence the experimental results as sediment N and P concentrations hardly changed during the experiment.

2.2. Treatments

Four treatments were applied: (1) control in which no cutting was applied, (2) cutting halfway the water column at approximately 17.5 cm depth, (3) cutting at three-quarter of the water column at approximately 26 cm depth and (4) cutting at the bottom without disturbing sediment and below-ground parts. All plant shoots were cut each time a single shoot reached the water surface. This implies that the number of cuttings was different between treatments. Four replicates per treatment were used resulting in 16 microcosms per plant species. The experiment was ended when plants in the control treatment started to show decay of leaves and stems which was after 160 d and 187 d for respectively *P. lucens* and *P. compressus*.

2.3. Data collection and analyses

Plant development was monitored by measuring the total length of all standing green shoots several times during the experimental period. This was done by placing a ruler in the microcosm and measuring all vertical shoots. On average this was done every 25 d.

Dry mass (g DW) was determined of shoots cut during the experiment, total shoots (sum of the shoots cut and shoots removed at the end of the experiment) and below-ground parts at the end of the experiment. Also total length (cm) of the shoots produced during the experiment was measured and the number of flowers and turions that developed during the experiment were recorded. Additionally mean dry mass per cm shoot was calculated for all collected green shoots. The data was analysed using ANOVA and Tukey-b posthoc tests in SPSS 17 (SPSS, 2009).

3. Results

3.1. Course of the experiment

Within 1 month after the start of the experiment all plants of *P. lucens* (Fig. 1A) started growing and within 3 months they all reached the water surface. Insufficient data was available for the period between the 6th of October 2009 and 11th of January 2010 to illustrate this development (Fig. 1). Total length of the shoots at 11 January was still comparable for all treatments. Thereafter total length of plants cut at the sediment–water interface hardly increased, while in the other treatments shoots continued their growth. Plants cut at three-quarters down the water column showed moderately lower values compared to the controls and plant cut halfway down the water column although standard errors were rather high. *P. compressus* (Fig. 1B) developed faster as within 1 month all plants had reached the water surface. From the 3rd of May, plants cut at the sediment–water interface showed less shoot development compared to the other treatments. At the final monitoring date some treatments had a lower mean value compared to the previous date (Fig. 1). This seems to be caused by a measuring error as all lengths of shoots were measured under water in the microcosms, except for the final measurement when lengths were measured after all shoots had been removed from the microcosms.

The first cuttings of *P. lucens* were on average performed after 85 d while for *P. compressus* this was after 31 d. After the first cutting, the average time in between cuttings was comparable for *P. lucens* and *P. compressus* being respectively 31 and 28 d. Compared to *P. lucens*, the number of cuttings was higher for *P. compressus* for cutting halfway and at three-quarters down the water column (Table 1).

Nutrient concentrations in the sediment were moderate (Bloemendaal and Roelofs, 1988) and hardly changed during the experiment (Table 2). The difference in total N in the sediment between the two experiments was caused by the two separate field visits in which the sediment for the two species was collected, although the sediment was collected at the same location.